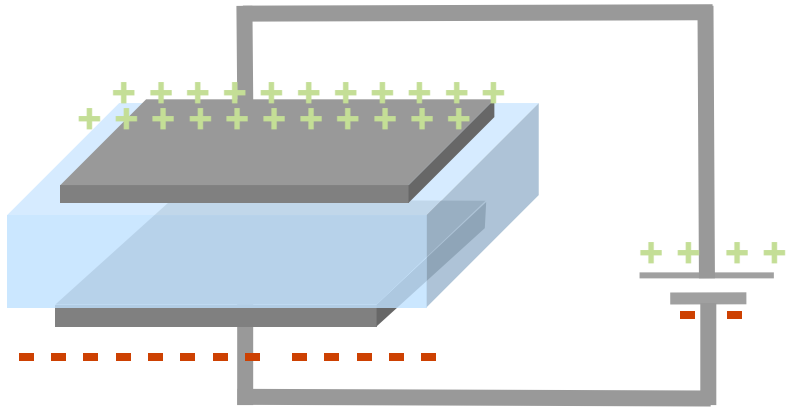
NEXIPAL® – inside next-generation sensors & actuators

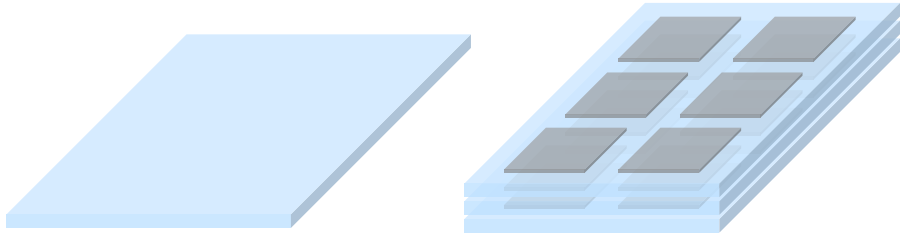
nexipal@wacker.com

WACKER

Creating tomorrow's solutions

NEXIPAL®: Dielectric EAP (ElectroActive Polymer) several layers stack for sensor and actuator applications





ELASTOSIL® Film
2030: sensor/actuator
624: fuel cells
3003: films from LSRs

NEXIPAL®
Sensor
Actuator

- **Silicone Film as insulating dielectric** in highly stretchable sensors or actuators
- **WACKER-development** and scaling of electrode materials
- **Printing of electrodes**
  Customized for individual applications & requirements (IP protected process)
- **Industrial roll-to-roll processes**
  Energy efficient solvent free production
- **Free of raw earth elements & heavy metals** energy-efficient manufacturing process
- **Latest Improvements lead to new products**
  ELASTOSIL® Film 3003 from high viscous LSR (Liquid Silicone Rubbers) raw materials now possible

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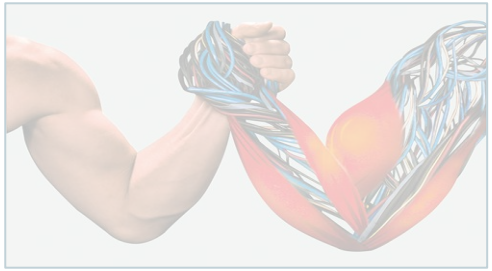
ELASTOSIL® Film offers strong USPs for the market development NEXIPAL® will be a key component in electroactive transducers

NEXIPAL®

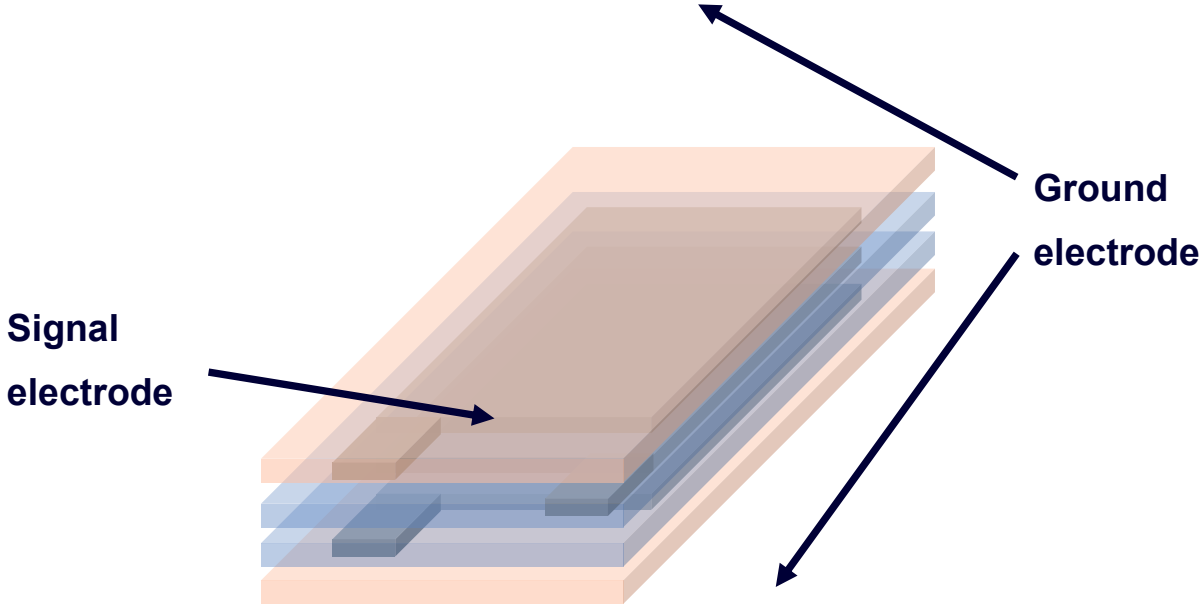
Sensor

Optimization and customization

Actuator

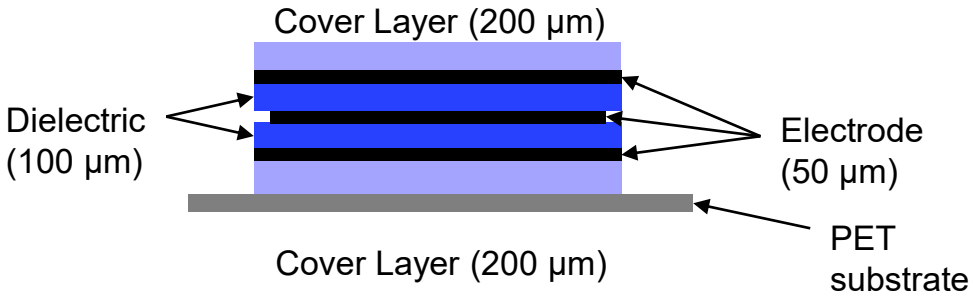


R&D priority



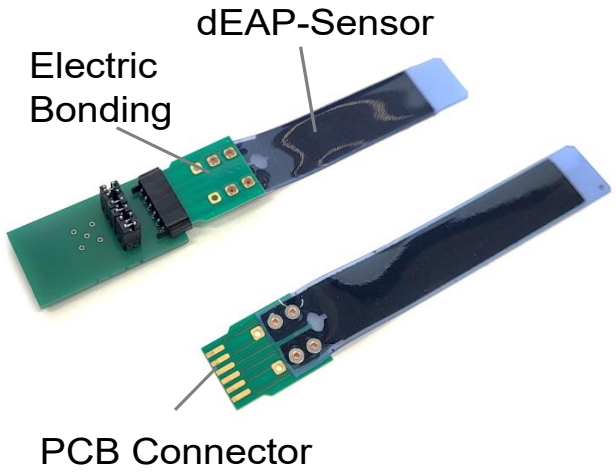
NEXIPAL® Sense

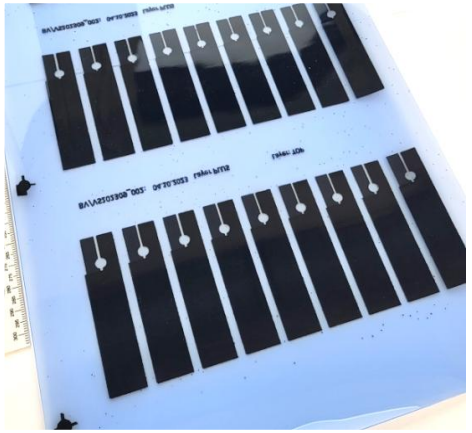
Shielded sensor 7 layers:



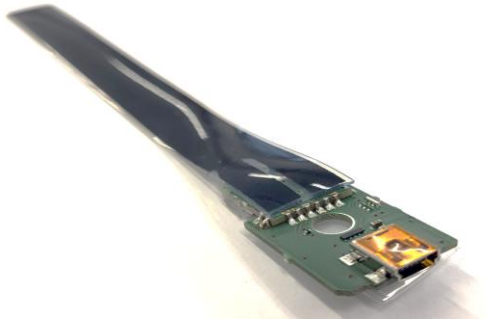
- Engineering sample: Stripe sensor (L < 80mm)
- Digital printing process → customized geometries possible
- Development partner including electronics:

Delfa systems



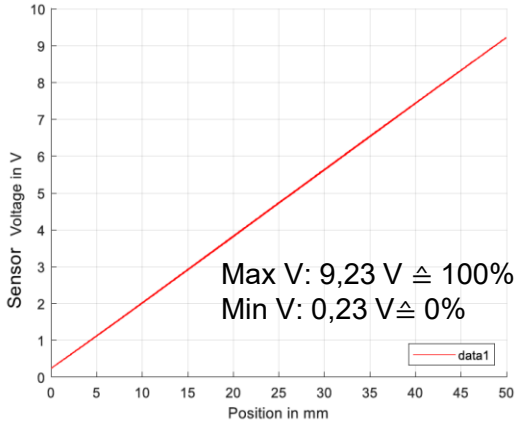


7 layer capacitive sensor, signal converted to voltage out
Sensor size: 15 x 50mm

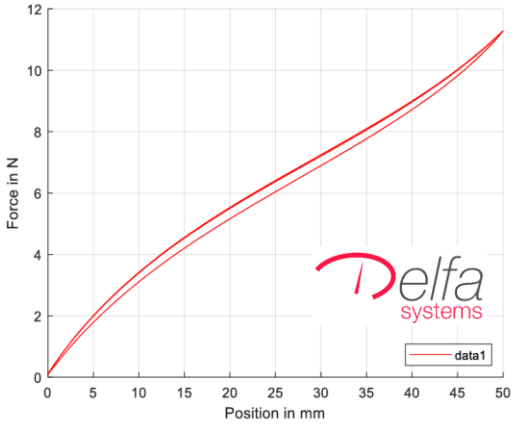


Initial capacitance: 230 pF (silicone stripe)
Initial spec. resistance: 15 ohm cm

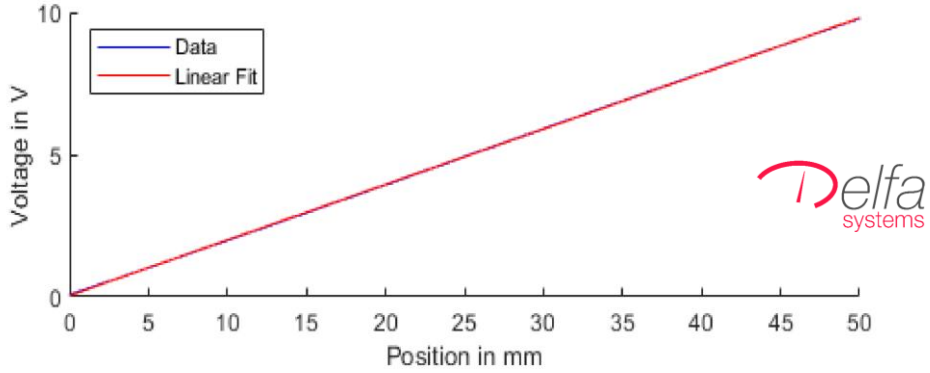
Resolution: 0,12 % (0,06 mm)



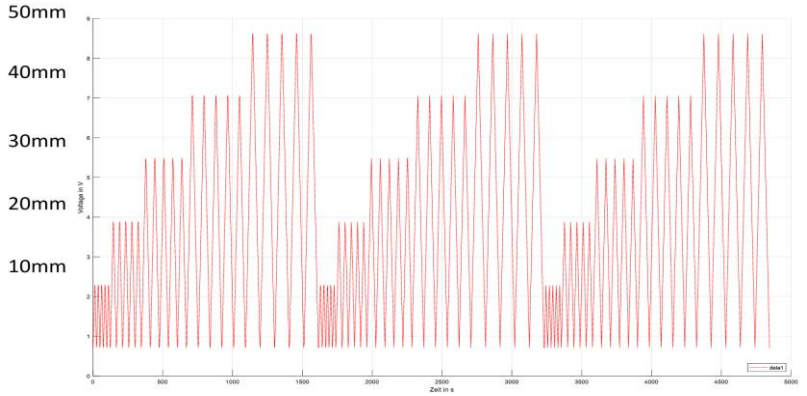
Force vs strain



Linearity: max error: 0,42 % (0,21 mm)



Repeatability: excellent (0,12 %)



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NEXIPAL® strain sensor evaluation kit available in two versions: USB incl. windows software or I²C bus connector

Sensor data sheet, double-klick to open

Position-/Strain Sensor

Datasheet DST-S1M4-XXX-5M8V-XX-XX-XX-XX-XX

Delfa systems

Properties

This robust and cost-competitive sensor enables position or displacement measurement across different applications. Being made of rubber, it tolerates installation misalignments while compensating for any measurement error due to misalignment hence making it ideal for retrofitting with a simple mounting process. The sensor is equipped with an in-built adaptable electronic that provides standard analog output as well as digital communication IOs. The digital IOs e.g. enable the adjustment of measurement range and alarm criteria – on-the-fly and without any need for mechanical adjustment.

- Rubber sensor tolerating misalignment, shocks, and vibration.
- Simple installation, perfect for retrofitting
- No additional measuring amplifier required (Plug and play)
- Intelligent electronics enabling alarm generation with on-the-fly configuration
- Highly customizable in shape, size, and range for applications with unique requirements
- High-resolution analog signal
- Compact size

Applications

- Crack, strain, and displacement monitoring of structures (**Structural Health Monitoring**)
- Displacement measurement of moving parts in **off-road and heavy-duty vehicles**
- Position measurement of **industrial actuators** for monitoring and automation
- Surface strain measurement of large industrial structures such as **wind mills, pipes**, etc.
- Displacement and angle measurement of **Soft Robots** for position control

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Position-/Strain Sensor

Datasheet DST-S1M4-XXX-5M8V-XX-XX-XX-XX-XX

Delfa systems

Technical Data

Weight	approx. 25g	Weight of sensor with electronic
Range	25 mm 50 mm 100 mm	Maximum displacement (Full Scale), others on request
Elongation force	<12 N	Force when stretched 100%
Resolution	0.1%FS up to 12 bit	Sensor: Smallest detectable output change Electronic: Resolution of DAC
Repeatability	<0.1%FS	Maximum error when stretched to same value
Drift	$5x10^{-4}$%FS/day	Creep over 24h at room temperature
Accuracy	0.5%FS	Maximum difference between output and ideal linear curve including noise
Temperature	0.08%FS/K	Uncompensated sensor drift per Kelvin
Humidity	0.02%FS/%rH	Uncompensated sensor drift per percent relative humidity
Digital IOs	In: max. 24 V Out: Open Drain, max. 24 V, 250 mA or 10 kΩ Pull-up	Function upon definition Resistive Loads only
Analog output	0...3.3 V 0...10 V 0...20 mA, max. 24 V 4..20 mA, max. 24 V	Proportional to sensor signal
Communication	UART	Programming Adapter is required, others on request
Sampling frequency	≤2 kHz*	Maximum refreshing rate of analog output
Operating temp.	-55°C to 80°C	Can be higher for sensor with separate electronic
Supply voltage	3.4 to 5.2 VDC 12 VDC +/- 20% 24 VDC +/- 20% 9 to 30 VDC +/- 20%	Others on request
Connector	M8 5 Pin B-coded	Different orientations or M12 on request

* specification performed at 125 Hz

Linearity and Hysteresis

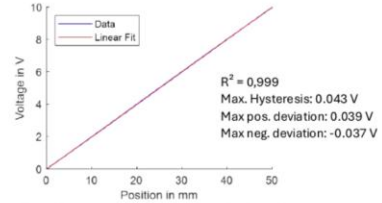


Figure 1: Typical sensor data (three cycles) and the linear fit

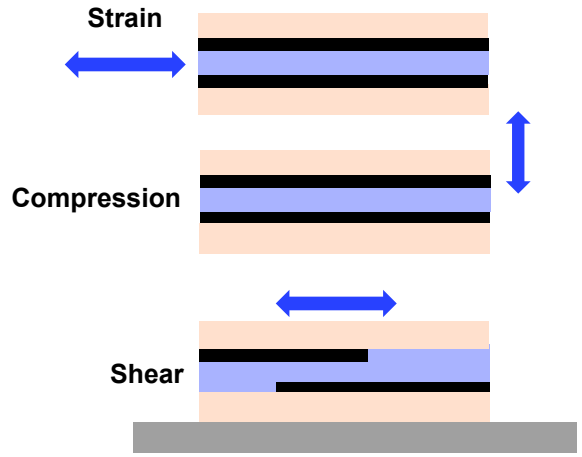
NEXIPAL® strain sensor sample kit to start customer developments

Starting point

- Sensor kit 1: **“Windows” USB, software”**
- Sensor kit 2: **Sensorkit I²C**
- **Sensor stripes only**

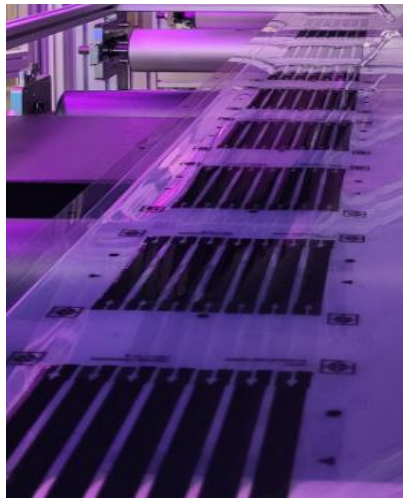
Capacitive sensors

- **Strain, compression or shear**
- **Absolute sensor** (measurement of thickness and area of the dielectric)
- **Not dependent on changes in the electrode material** (in contrast to resistive measurement)
- **Temperature compensation** (CTE)



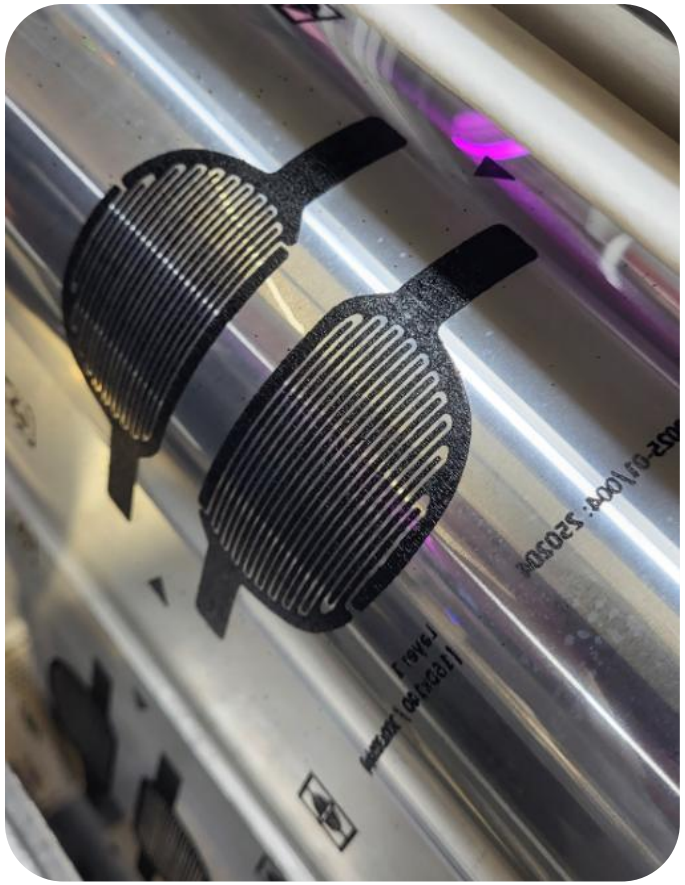
Customized sensor

- **Can be calculated and simulated**
- **Adjustment of the design** to the measurement problem (layer thicknesses, number of layers, geometry
- **Design rules** are provided
- **Digital printing process**

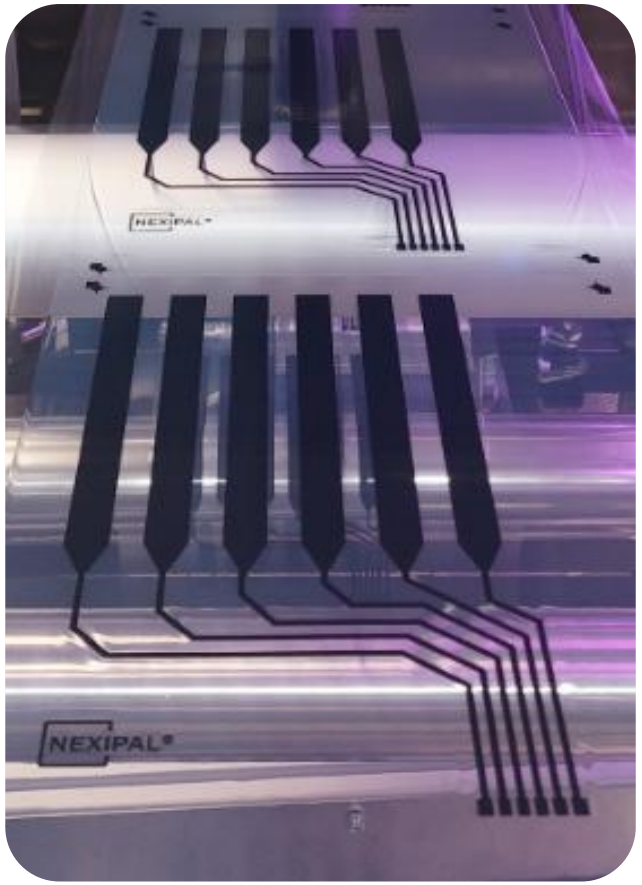


Silicone Films and NEXIPAL®, nexipal@wacker.com

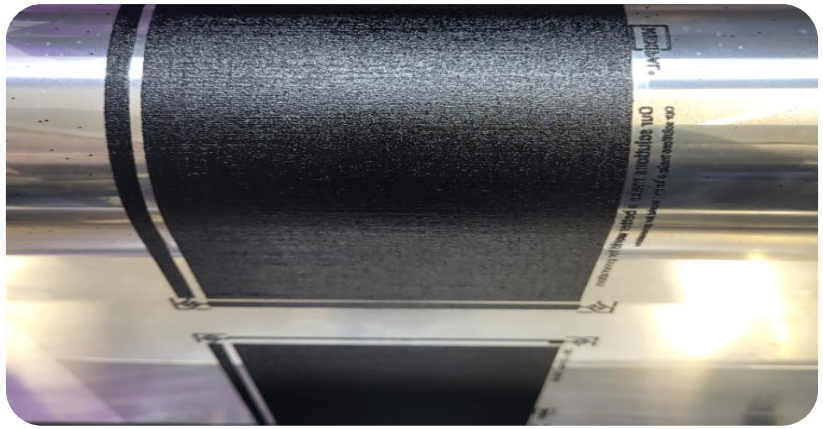
Different geometries and thicknesses can be easily realized

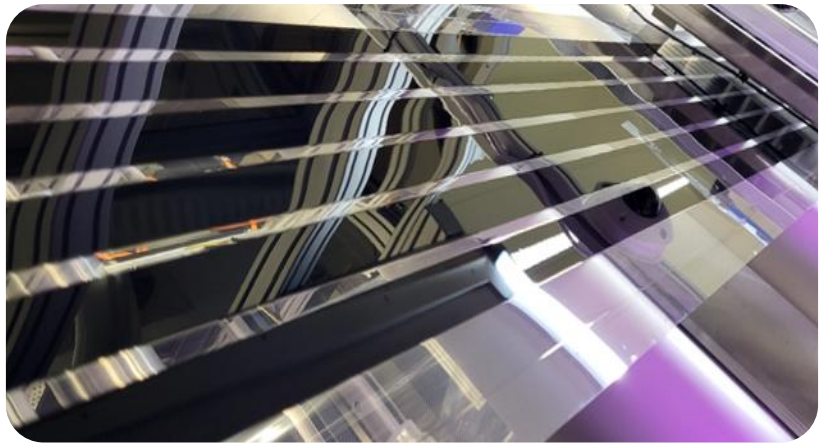


Electrostatic grippers



Stripe sensing array

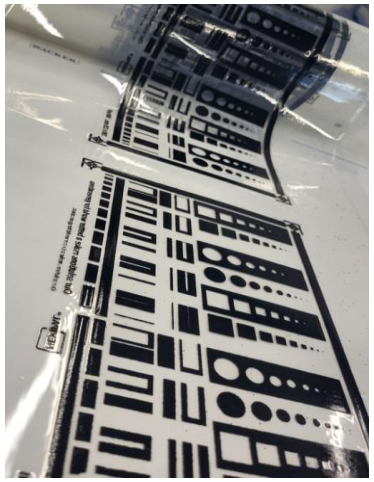


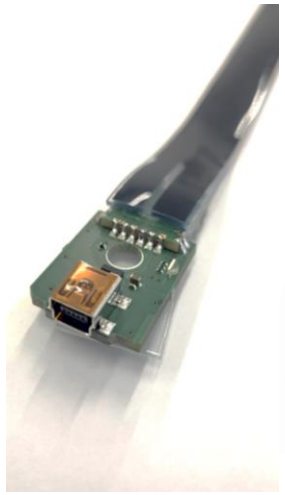


Multi-layer endless strips

NEXIPAL®: Dielectric EAP Several Layers for Sensor and Actuator Applications Based on Silicone Film Technology







silicone chemistry and laminate manufacturing

system design and electronics

Silicone & Electrode formulation → ELASTOSIL® Film → Electrode printing → Multilayering and cutting → stacking & bonding → device build up connection → system integration electronics software

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CUSTOMER

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ELASTOSIL® Film
ELASTOSIL® Film LSR
SILPURAN® Film

The future generation of silicone films

nexipal@wacker.com

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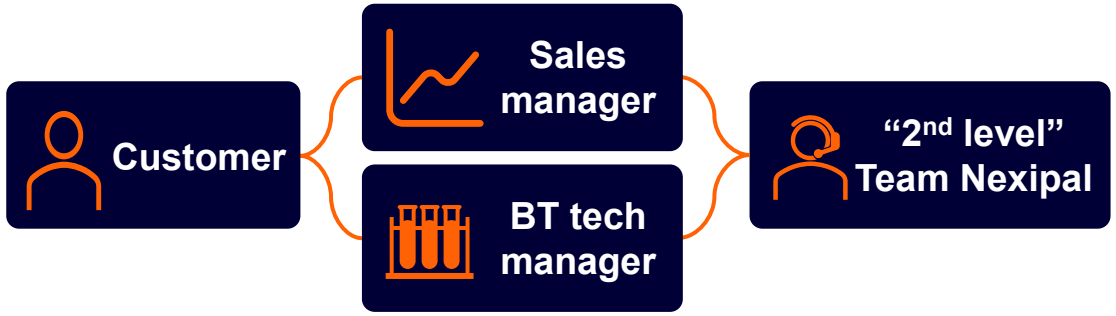
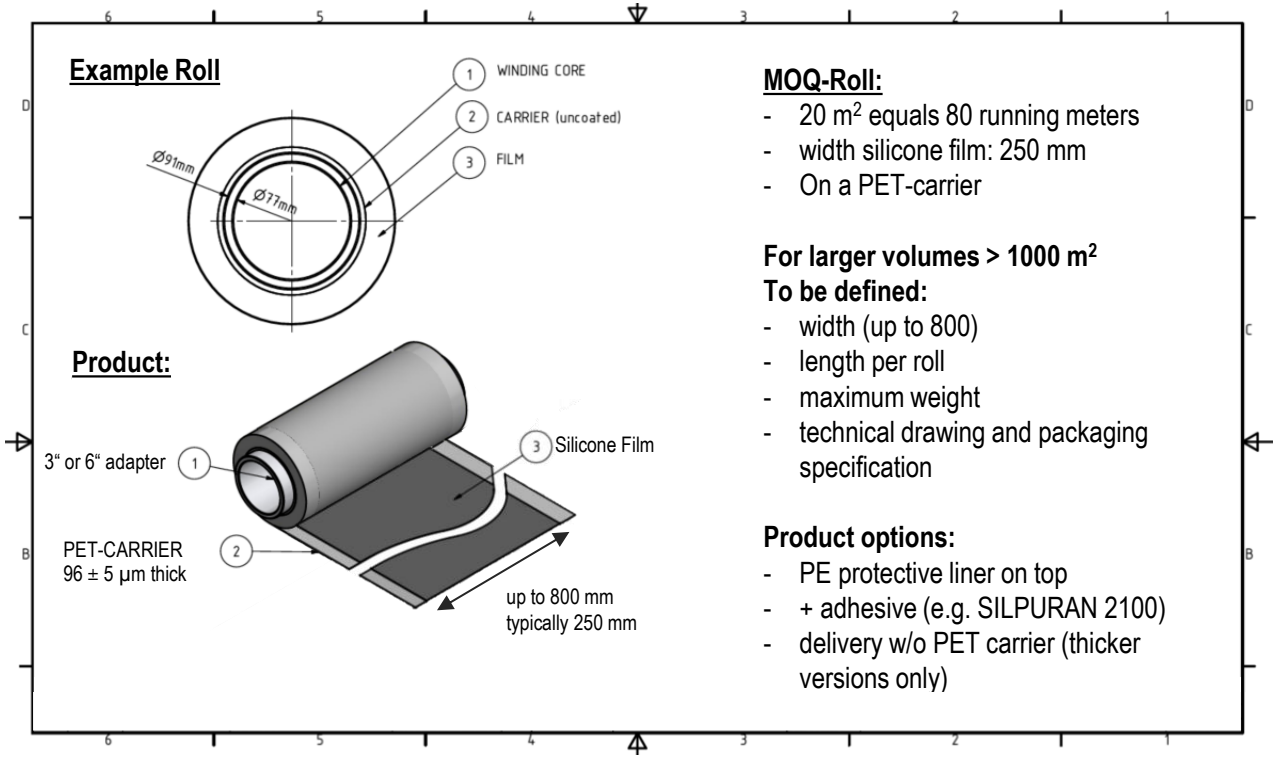
Creating tomorrow's solutions

Silicone Films from 100 % crosslinked silicone rubber

Setting

- **Forward integration** as a part of WACKER to produce silicone films
- **Roll-2-roll** process for maximum efficiency
- **Routine production** on 2 lines in Burghausen (Lindach) by silicone operations
- **Scaled clean room** production
- **Cutting and converting** options
- Use of **standard silicone raw materials** (RTV-2s and LSRs)
- **Portfolio:** see sample folders, other WACKER materials possible





C. Berghammer J. Neuwirth A. Köllnberger K. Eller

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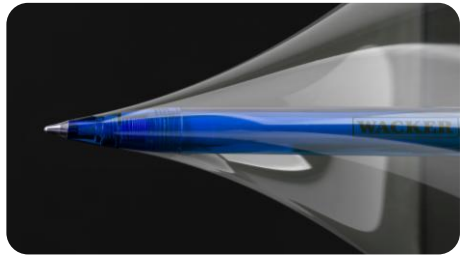
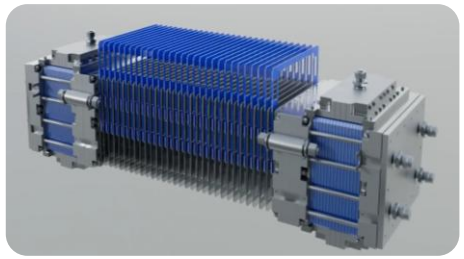
ELASTOSIL® Film and SILPURAN® Film made from LSR and RTV-2 silicones under clean room conditions

Silicone Film

ELASTOSIL® Film 2030 SILPURAN® Film 2030	ELASTOSIL® Film 3003 ELASTOSIL® Film 630	ELASTOSIL® Film 624
• **Thickness:** 10 µm – 400 µm • **Precision:** ± 7 % ≤ 20 µm ± 5 % > 20 µm • **Base:** RTV-2	• **Thickness:** 0,4 – 2 mm • **Precision:** ± 10 % • **Multi-purpose grades** ELASTOSIL® LR 3003 series POWERSIL® XLR 630/35 • **Silicone adhesive layer** SILPURAN® 2114, 2100	• **Fuel Cell approved** for routine automotive production • **Thickness:** 150 – 500 µm • **Precision:** ± 5 % • **Low compression set**





General information

- **Silicone Film on a roll** delivered on a PET carrier
- **Roll width** up to 800 mm
- **Clean room** production
- **In-line thickness** measurements
- **In-line defect inspection** 100 % controlled
- **Lot and linear meters** printed on the product
- **SILPURAN® Film & Adhesive:** USP Class VI
- **MOQ:** 20 m2
- Several grades **readily available,** other raw materials possible

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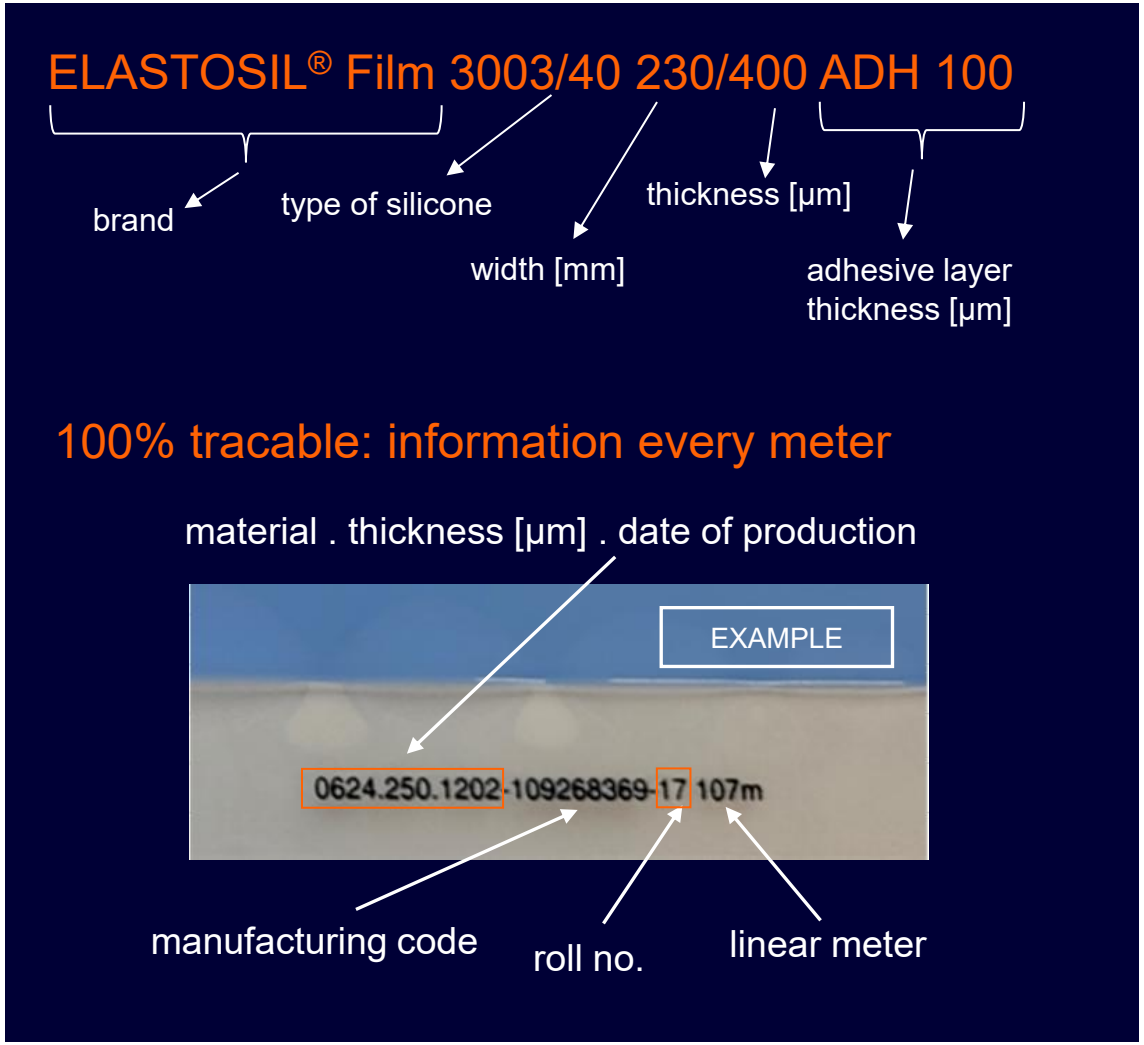
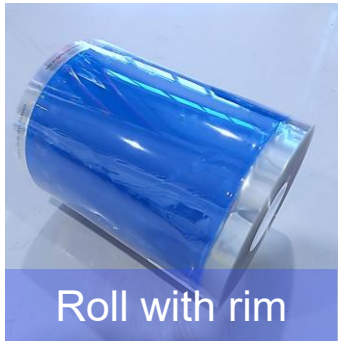
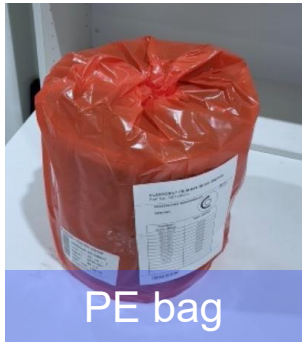
Silicone Films – general information



- All products from the sample folders:
  MOQ rolls 20 m² on stock
  20 m² equals 80 linear meters, 0,25 m wide
- **Customized versions** possible
- **Insights article incl. Q&A**
  [Pushing boundaries with ultra-precise, next-generation silicone films: ELASTOSIL® Film LSR - Wacker Chemie AG]





ELASTOSIL® Film from LSRs sample box

Nr.	Type	ShA	Width [mm]	Thickness [µm]	Color
1 - 3	EL FILM 3003-20 TR 250/xxx	20	250	400, 600, 800	-
4 - 6	EL FILM 3003-30 250/xxx	30	250	400, 600, 800	-
7 - 9	EL FILM 3003-40 250/xxx	40	250	400, 600, 800 (800: RAL 3027)	Red
10 – 12	EL FILM 3003-60 250/xxx	60	250	400, 600, 800	-
13	EL FILM 630 250/200	35	250	200	Grey
14	EL FILM 3003-40 230/400 / ADH 100	40	230	400 (film) + 100 (adhesive layer, SILPURAN® 2114)	-
15	EL FILM 3003-40 230/600 / ADH 200	40	230	600 (film) + 200 (adhesive layer, SILPURAN® 2114)	-
16	EL FILM 630 230/100 / ADH 100	35	230	100 (film) + 100 (adhesive layer, SILPURAN® 2114)	Grey
17	SIPURAN® Film 6000/40 250/600	40	250	600	

How to order: Europe: Wacker Give Aways – Home
Other: Please contact team NEXIPAL®

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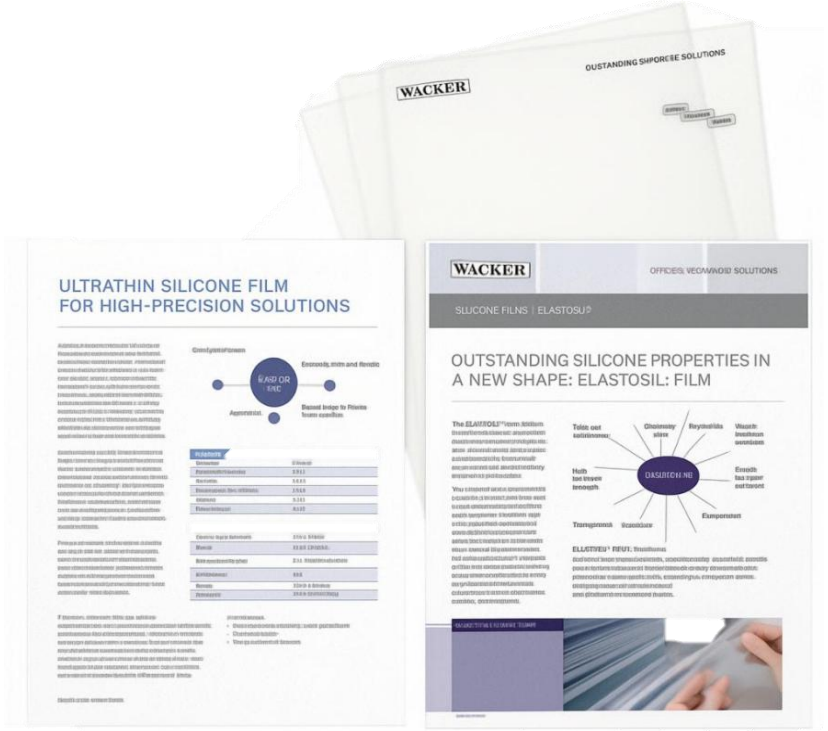
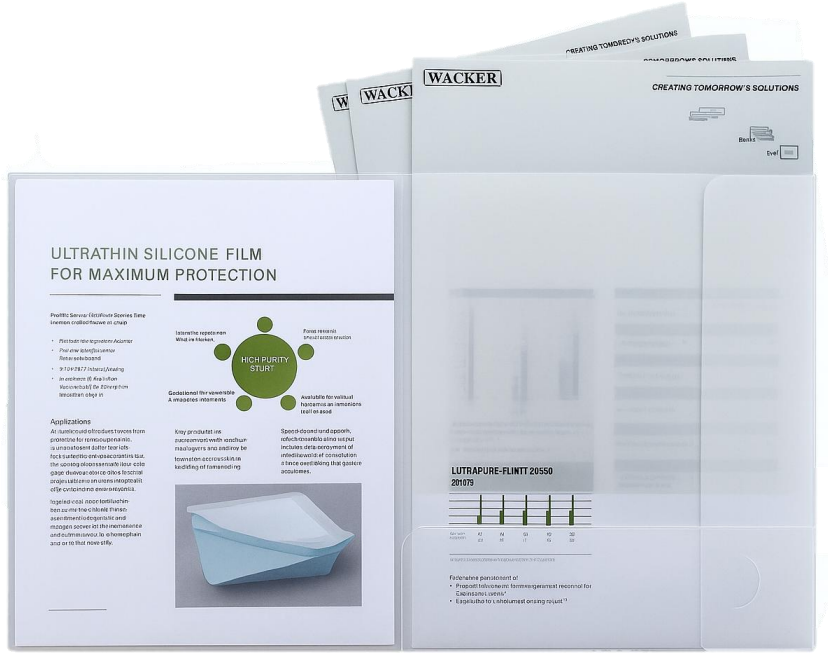
ELASTOSIL® Film 2030 and SILPURAN® Film 2030 sample boxes

ELASTOSIL® Film 2030 250/XX:
20 µm, 50 µm, 100 µm, 200 µm (1 pc each)



SILPURAN® Film 2030 250/XX:
20 µm, 50 µm, 100 µm, 200 µm (1 pc each)



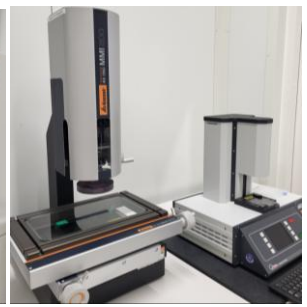
How to order: **Europe:** Wacker Give Aways – Home **Other regions:** Please contact team NEXIPAL®

New Location at Burghausen/Lindach centralizes innovation and series production for ELASTOSIL® Film and NEXIPAL® laminates

Innovation hub
Lindach, BGH
Germany

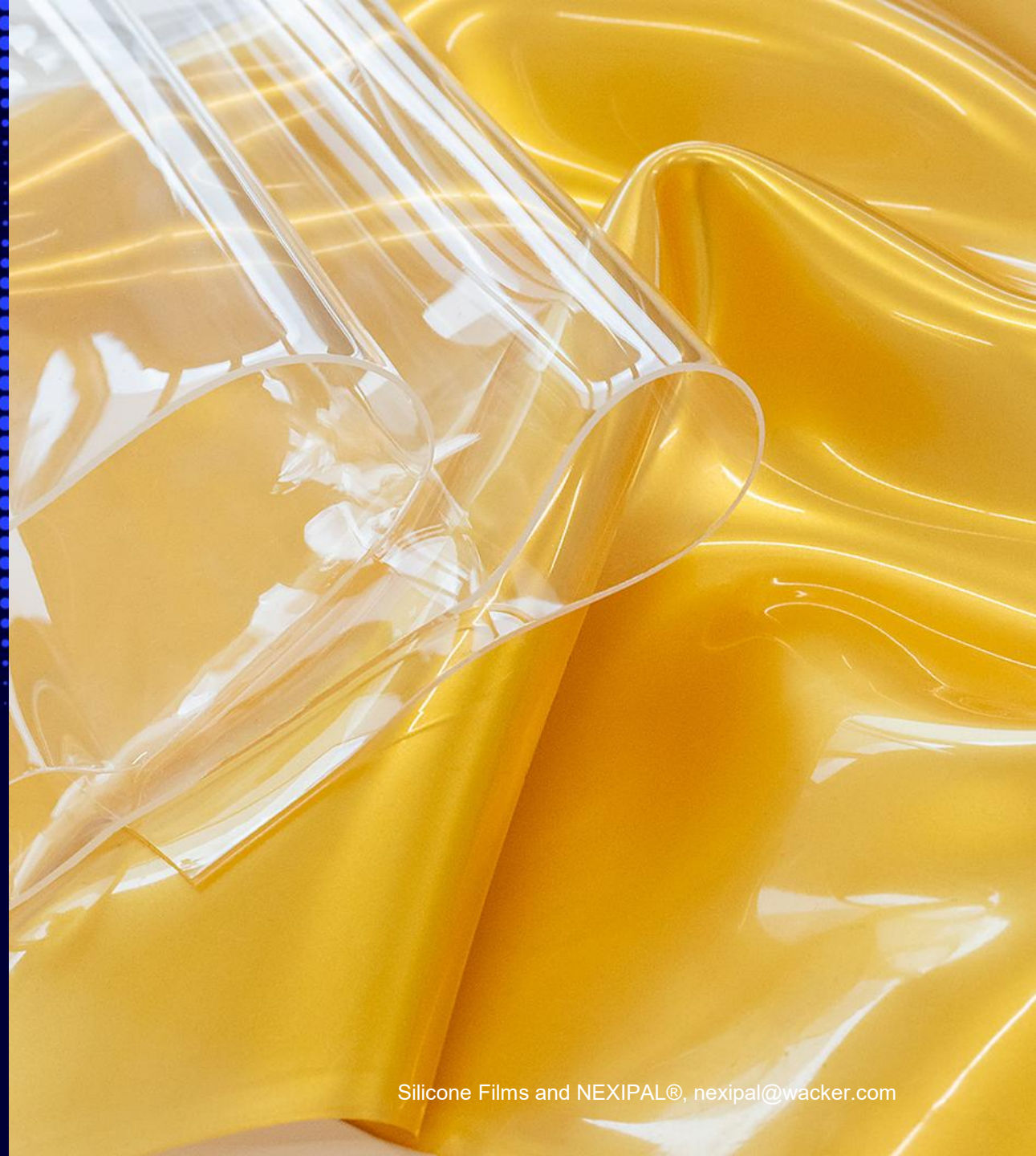
Production
“TechLine”
(600mm width)

Labs
test
benches



Production
“NewLine”
(800mm width)

Thank you for your attention



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